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A.R.L. / L/N113

ONE-YEAR COLLECTION OF LONG-RANGE
ECHO RECORDS OF FISH BEHAVIOUR

BY

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111

JULY 1964

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A ONE-YEAR COLLECTION OF LONG-RANGE ECHO RECORDS
OF FISH BEHAVIOUR

by

D. E. Weston
J. Revie
G. Wearden

ABSTRACT

Echo-ranging records have been obtained at Perranporth over a period of about one year, some being continuous over several days. Broadly speaking there are three types of trace, all of them at least partly biological in origin:- wrigglers, fixed bottom echoes and diffuse patterns. Fish behaviour is displayed continuously out to 40 miles, and is especially complex near dawn and dusk.

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36 pages
12 figures

- 1 -

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INTRODUCTION

Some experimental bottom-laid echo-ranging equipment has provided many false targets and interesting patterns due to fish. The earlier work, up to about February, 1963, has been described in [1]. This reference also provides a general introduction to the investigations. In March, 1963 a new drum recorder [2] became available, which made it possible to display all ranges out to 40 nautical miles on teledeltos paper. This was very successful in speeding up the research considerably, and despite the frequent absence of the recorder on other work a large number of records have been obtained. There is a problem in analysing and reporting the great quantity of information generated, and therefore a collection of records is presented here with a relatively brief commentary. It is intended to report on various features in more detail later; including the positions of the fixed bottom echoes, the geometry of the diffuse patterns, some special experiments with ships and the effects of changing pulse type and frequency.

2. EQUIPMENT AND RECORDS

These echo-ranging experiments have been carried out in the shallow coastal water off Perranporth, Cornwall. The projector transmits 1000 c/s pulses of 4 sec duration with a linear gliding tone swept through a bandwidth of 100 c/s, the acoustic level being + 127 dB re 1 dyne/cm² at 1 yard. The receiver has a beam-width of 4° centred on 350°, and the correlation processing gives an effective range-resolution of about 25 feet [1].

The records shown were taken between 19th March, 1963 and 9th May, 1964, starting when the drum recorder first became available and finishing just before some major detection and fishing experiments in May and June, 1964. It was originally intended to present the records from one complete year, but unfortunately the projector was out of action from mid-December, 1963 to April, 1964. The records are reproduced as figures 1 to 12. Note that a single drum record is normally 68 in. long by 16 in. wide, and the reduction by a factor of about 8 to a half-tone print has inevitably caused some loss in detail. Some of the displays are virtually continuous over several days, produced by photographic montage. For example the August records in figure 7 span 10 days, and were recorded during experiments with A.C.S. ST. MARGARETS. All suitable records of reasonable length have been included, provided they were taken with full-power gliding-tone pulses in the main or 350° beam, in order not to create (nor to appear to create) a false impression by the exclusion of the duller records. Note that this was not true of the first report [1], where records were selected from a total about half as great again in order to illustrate the different types seen. The present records were all taken with one drum rotation every 100 sec (corresponding to about 40 nautical miles), and many also with one pulse every 100 sec. The remainder had one pulse every 50 sec (so that only 20 miles of range is displayed), and although included here for completeness are really parts of special investigations to be reported separately.

3. FEATURES OF RECORDS

(a) Wrigglers

As described in [1] the wrigglers are the discrete echoes from moving targets which show marked seasonal, tidal and diurnal effects. They are firmly ascribed to shoals of pelagic fish.

(b) Fixed bottom echoes

The fixed bottom echoes are the discrete echoes which appear at a constant range, though having a highly variable level. The present records show large and repeatable diurnal variations in August, as discussed in section 3(e). On a few occasions wrigglers have been seen to approach and to turn into fixed bottom echoes, and vice versa. This confirms the suspicions in [1] that the echoes are partly biological in origin, the biological part probably being due to bottom-feeding round fish living near rocks.

(c) Diffuse patterns

The diffuse patterns occur mainly at night, and are basically due to mode interference modulating the general reverberation background [1]. The mode interferences also modulate the fixed bottom echoes, which is apparent at the closer ranges. There are also examples of mode patterns affecting the wriggler traces in the daytime (e.g. 9th July, figure 6).

The night-time diffuse patterns are sometimes surprisingly regular (e.g. 23rd/25th May, 1963, figure 4), and show the effect of the tidal water depth changes. However, they are sometimes very confused, and this is apparently due to the variations in the concentration or scattering strength of the background reverberators. Comparison of the records before and after dawn or dusk often shows a strong correlation with the concentration of wrigglers (e.g. 14th-18th May, 1963, figure 3). Thus a major cause of the diffuse reverberation is now known to be fish, very likely the same pelagic fish that form the wrigglers though no longer in schools.

(d) Variability

It has become increasingly clear that one must not expect simple and repeatable patterns; variability is the keynote. In some records all the effects seem to act together and cause confusion and chaos (e.g. 11th-15th June, figure 5).

(e) New Features

Since the first report [1] many completely new effects have been observed, and even more suspected. The more definite ones all concern the diurnal cycle of behaviour, especially near dawn and dusk.

The fixed bottom echoes sometimes disappear very sharply (within a few minutes) at dusk, at the same time as the wrigglers i.e. 40 min. after sunset (August, figure 7). There is a similar though less marked effect before dawn. The bottom echoes are often strongest in the period from sunset to (sunset + 40 min), in the corresponding period before dawn, and for a few hours in the middle of the night.

The general dark reverberation background is sometimes much lighter from sunset to (sunset + 40 min) in the August records (figure 7). There is an alternative and more marked effect in which the lightening of the background, together with the fixed bottom echoes, occurs from (sunset + 40 min) to about (sunset + 70 min). The records show a corresponding light strip before dawn.

These new dusk and dawn effects are presumably controlled by the light intensity, as for the more commonly observed wriggler disappearances and appearances. They could be target effects due to changes in depth or concentration, as for the wrigglers. Alternatively they could be acoustic attenuation effects, and this idea is supported by signal level measurements near dusk and dawn taken a few days later. These show level changes of the order of 30 dB occurring over periods of several minutes in one-way transmission from Perranporth to Pembroke, and not observed previously. The necessary attenuation might have been distributed along the track, or concentrated near the transducers at either end. The observations and possible mechanisms will be discussed more fully in a separate note. The point to remark here is that the August echo-ranging records show an abrupt change at virtually all ranges - suggesting that the acoustic projector becomes decoupled from the water by being surrounded by fish!

4. SIGNIFICANCE OF INVESTIGATIONS

As discussed in [1] this work was started because of the military interest in the classification problem, but it is also giving information on oceanography and on fish behaviour. Regarding classification, the experiments on frequency diversity, pulse type and doppler will be reported separately. The oceanographic information mainly concerns tidal streams and tidal depth changes, and there is little new to say. It has become more and more clear that the system is a very powerful tool for the study of fish behaviour.

A further bonus has been obtained in the testing of the general system performance and the estimation of submarine detection ranges. For example even in summer conditions fish have often been detected at ranges exceeding 20 miles. The best summer range on a submarine is only 18 miles with this equipment, and then only when the target has dived to about 100 feet. The better results with fish are due to the fact that fish are present virtually all the time (at any rate in daytime) and at virtually all ranges, so that it is much easier to find the true detection limits.

5. CONCLUSIONS

Since this report is mainly a collection of records, detailed conclusions will not be drawn.

However, it is worth saying that we now know that wrigglers, fixed bottom echoes and diffuse patterns are all at least partly biological in origin (probably due to fish). The work is valuable in several fields, in particular the system is proving to be a very powerful tool in fish behaviour studies.

D. E. Weston (PSO)
J. Revie (EO)
G. Wearden (EO)

REFERENCES

1. WESTON, D. E. and REVIE, J., Wrigglers: False Targets due to Fish on a Long-Range Echo Display, A.R.L./L/R47 (1963) CONFIDENTIAL
2. BOUFFLER, J. A New Range Recorder ARL/L/N123, 1964

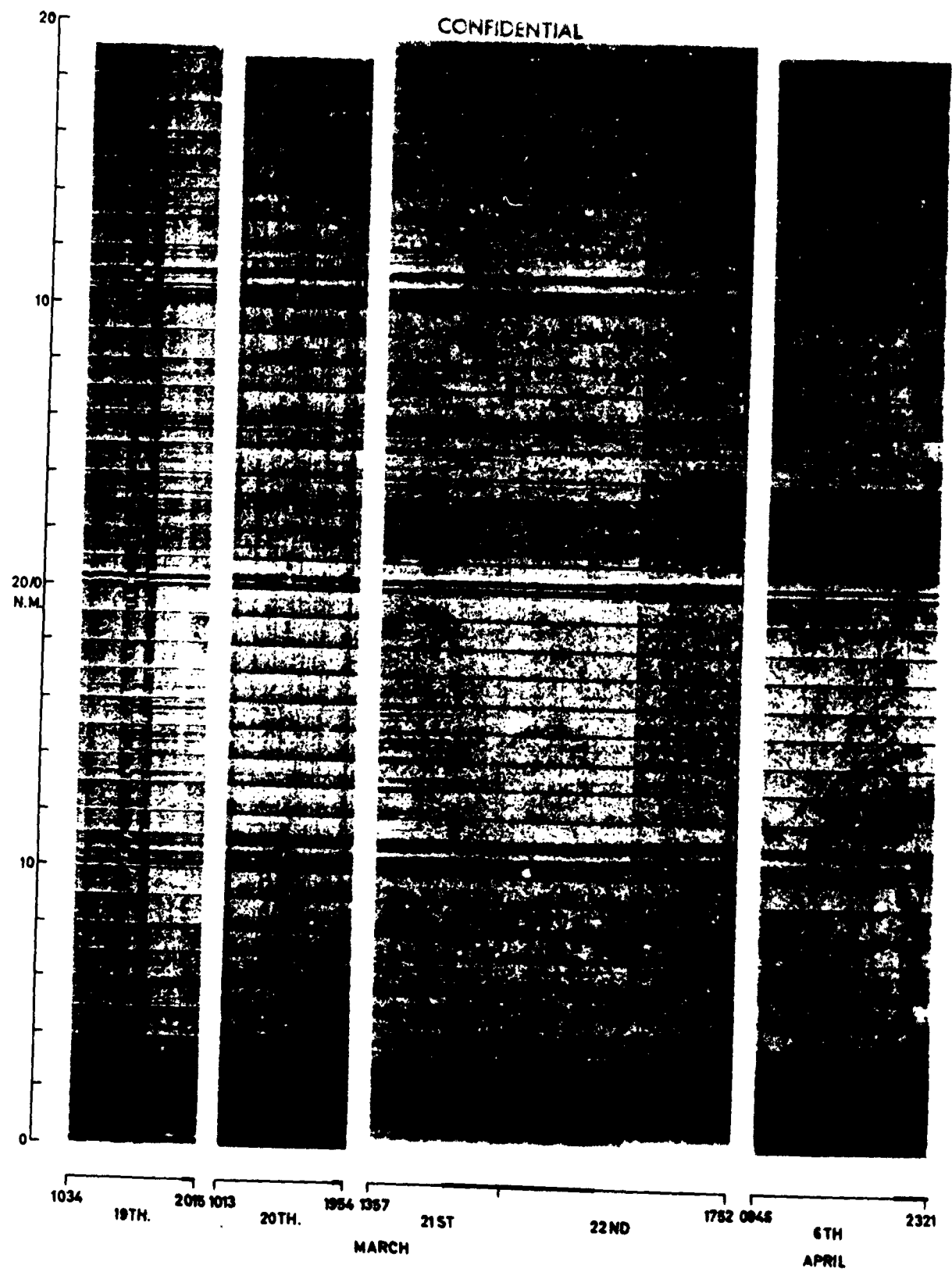


FIG.1 EARLY DISPLAYS BETWEEN 19TH. MARCH AND 6TH. APRIL 1963

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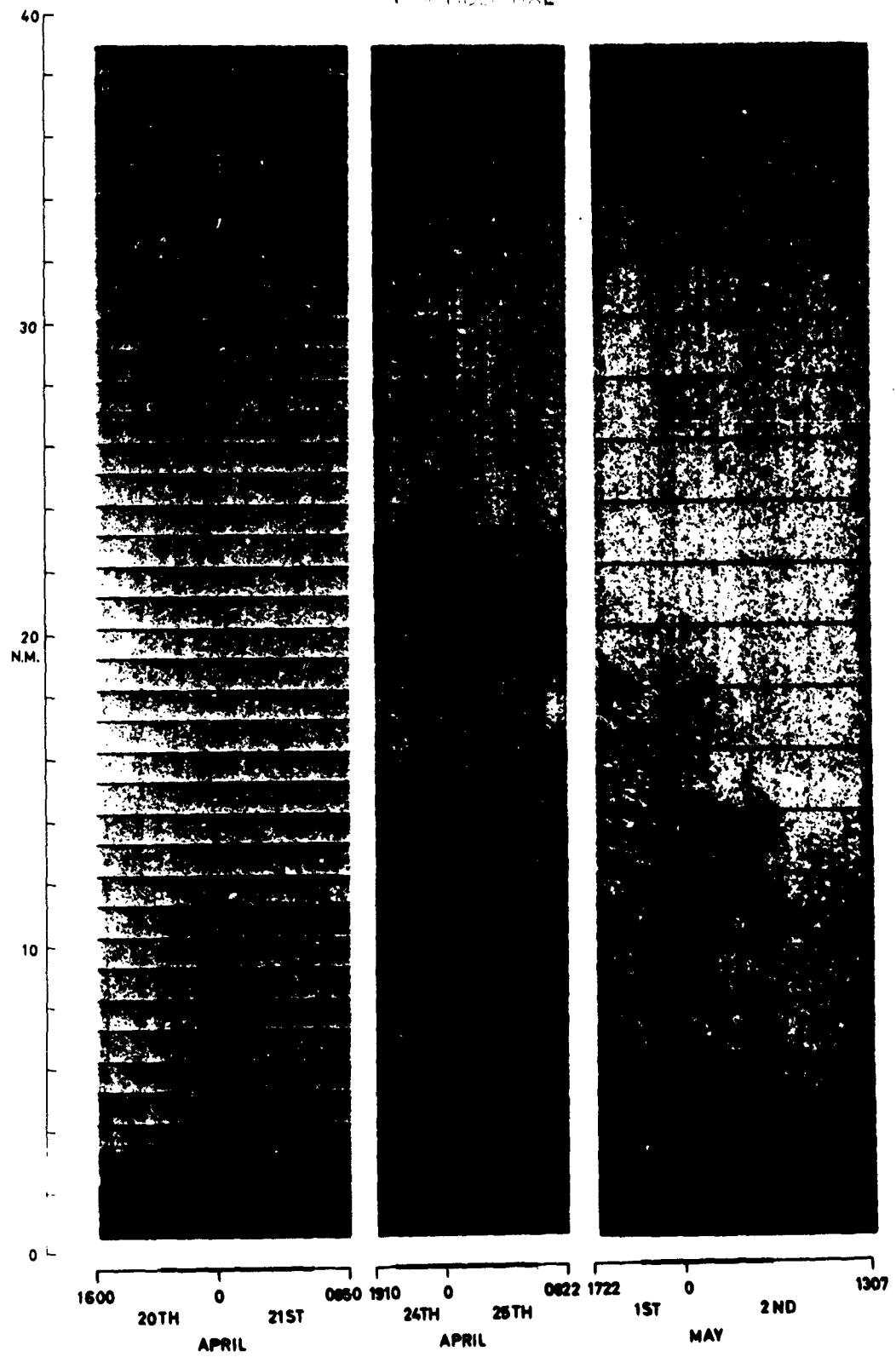


FIG.2 EARLY DISPLAYS BETWEEN 20TH. APRIL AND 2ND. MAY 1963

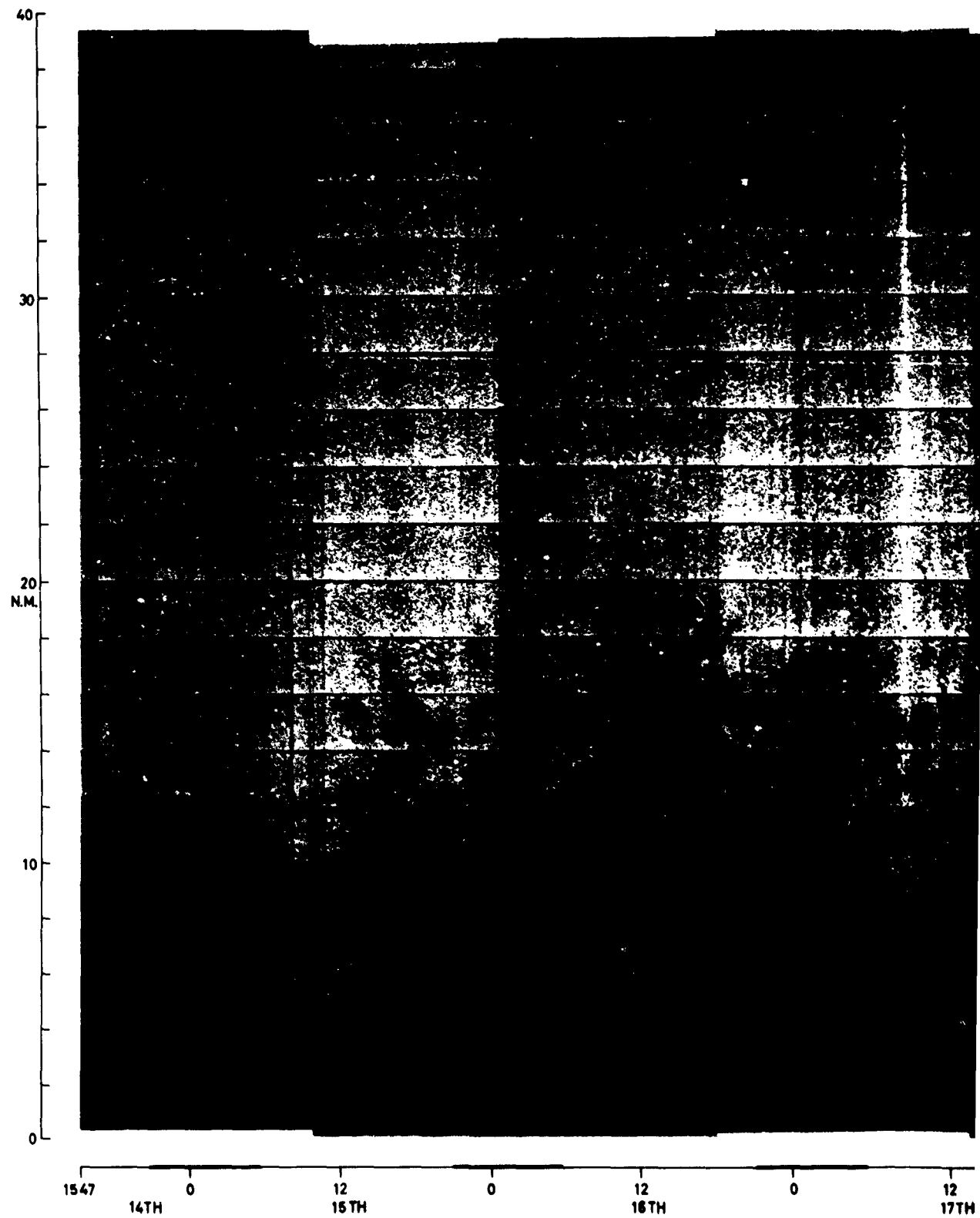


FIG.3 CONTINUOUS DISPLAY FROM 14TH. TO 18TH. MAY 1963

1

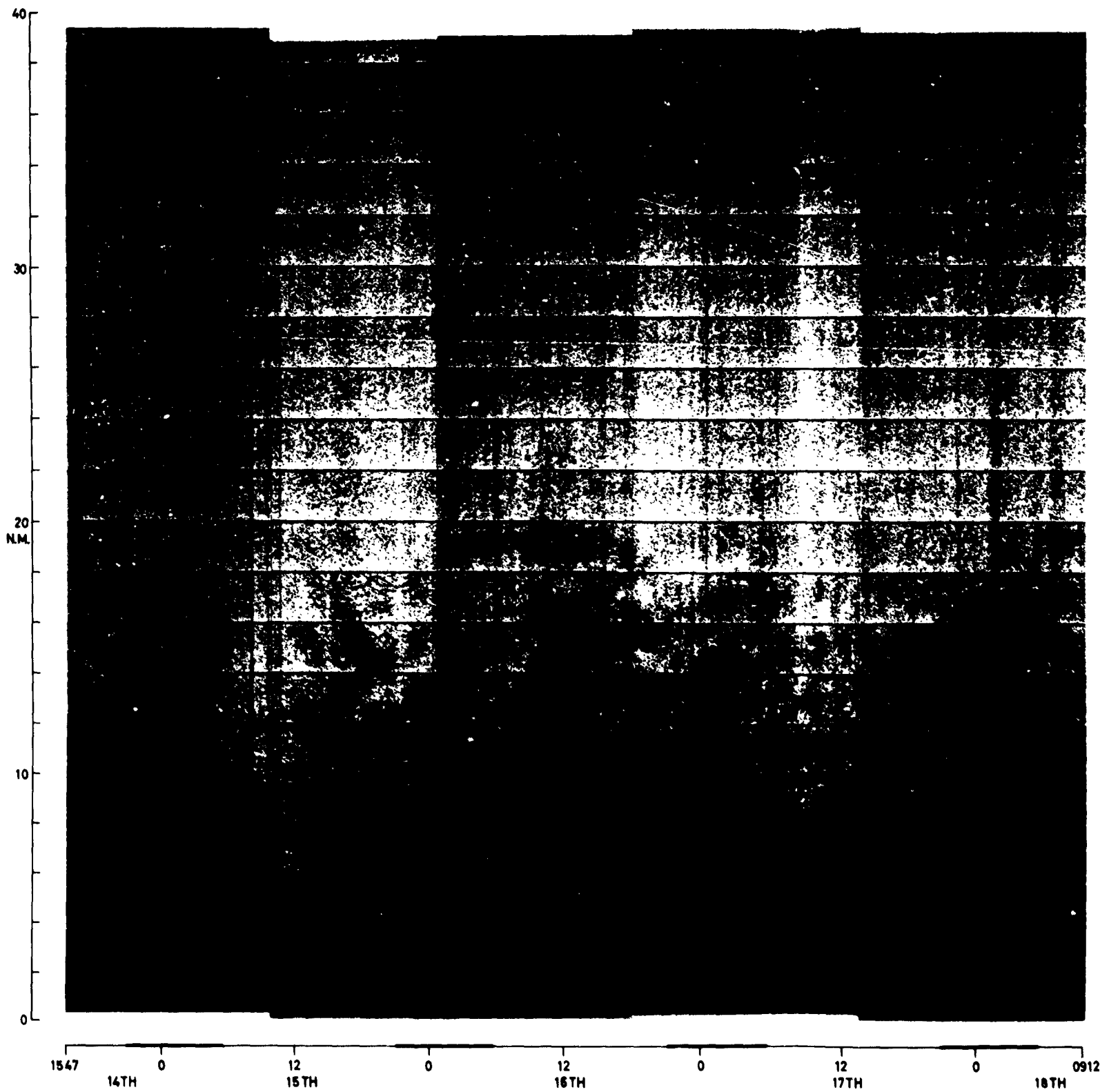


FIG.3 CONTINUOUS DISPLAY FROM 14TH. TO 18TH. MAY 1963

2

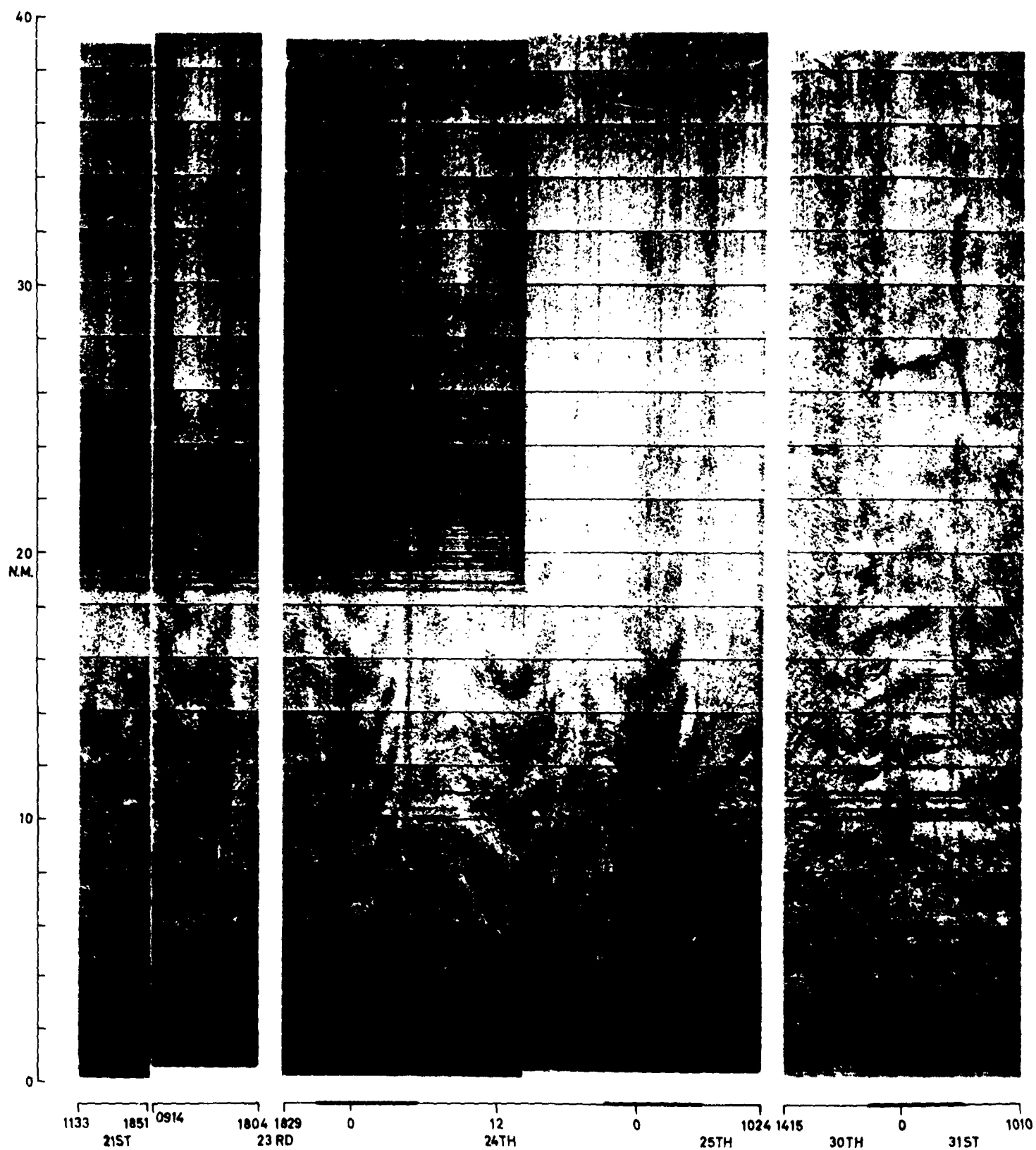


FIG. 4 DISPLAYS BETWEEN 21ST. AND 31ST. MAY 1963

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FIG.5 CONTINUOUS DISPLAY FROM 11TH. TO 15TH. JUNE 1963

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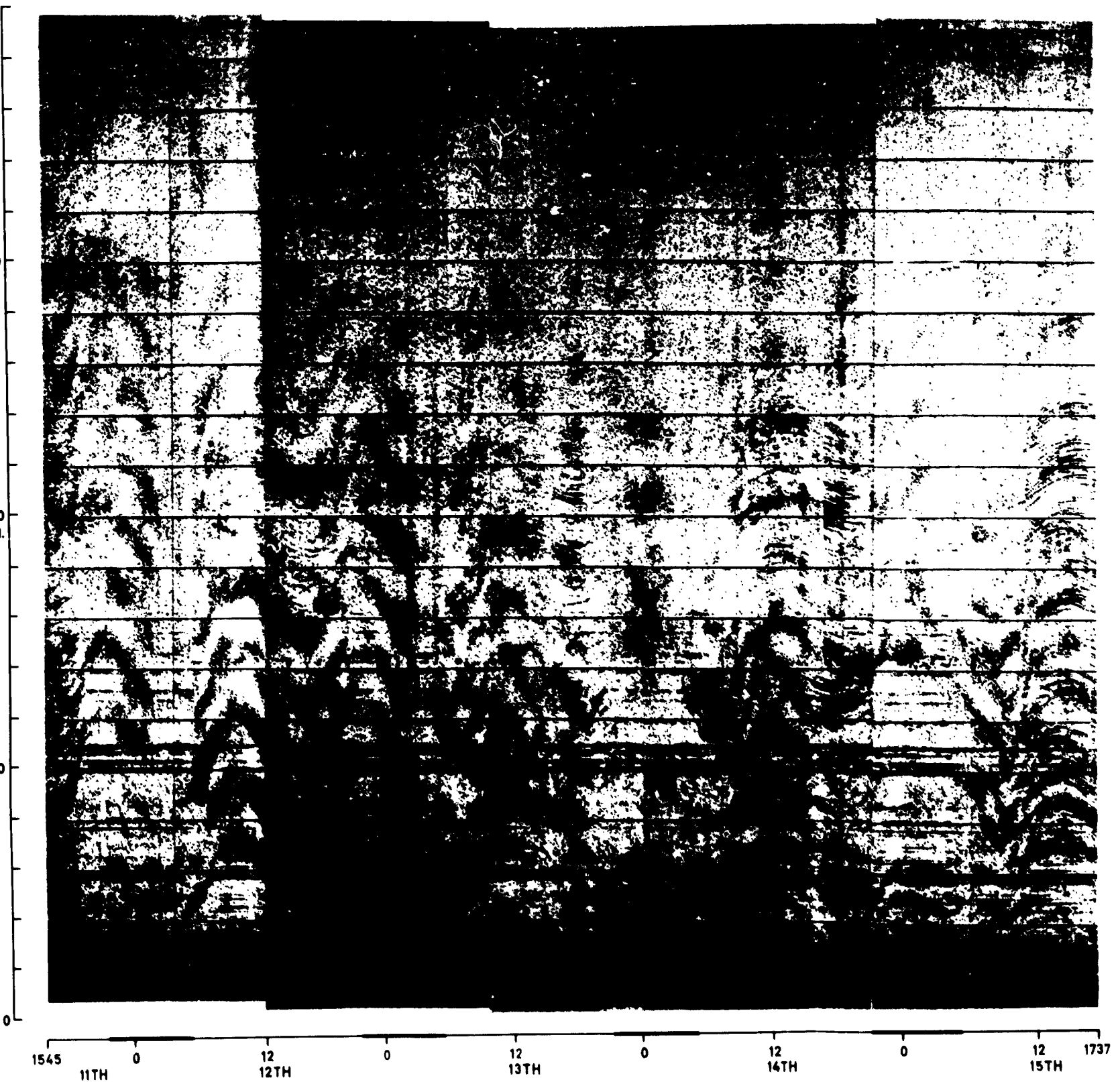


FIG.5 CONTINUOUS DISPLAY FROM 11TH. TO 15TH. JUNE 1963

2

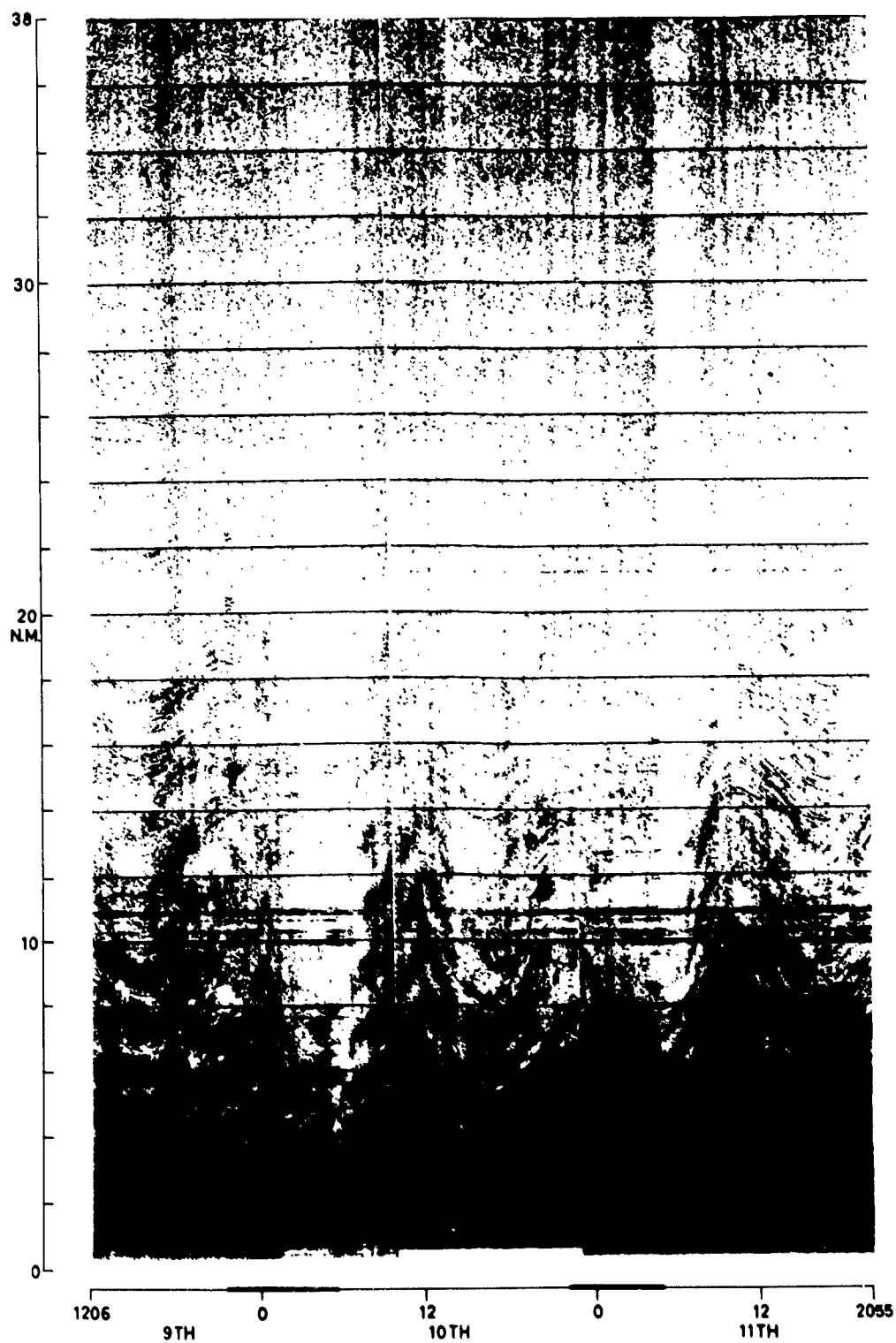


FIG.6 CONTINUOUS DISPLAY FROM 9TH. TO 11TH. JULY 1963

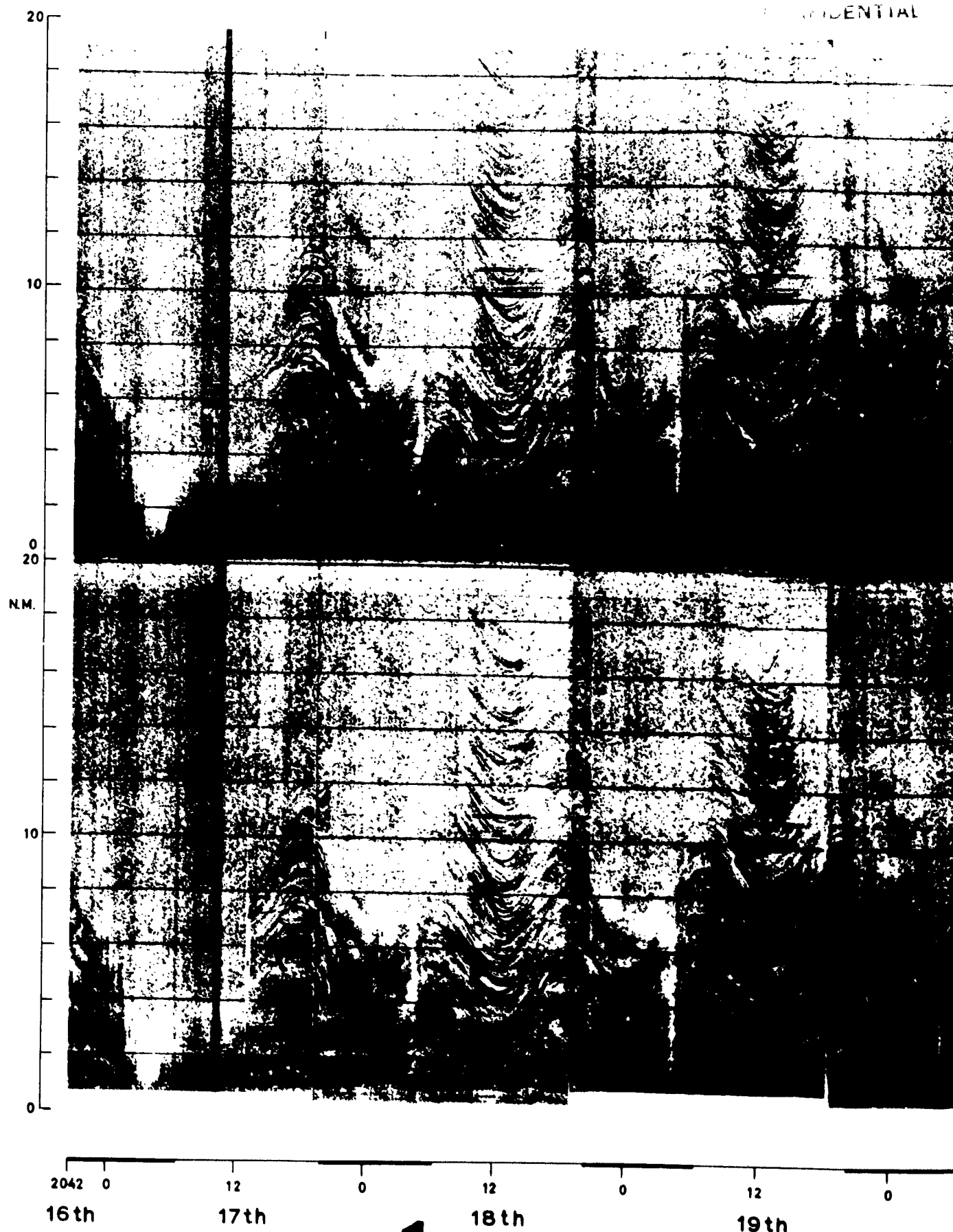
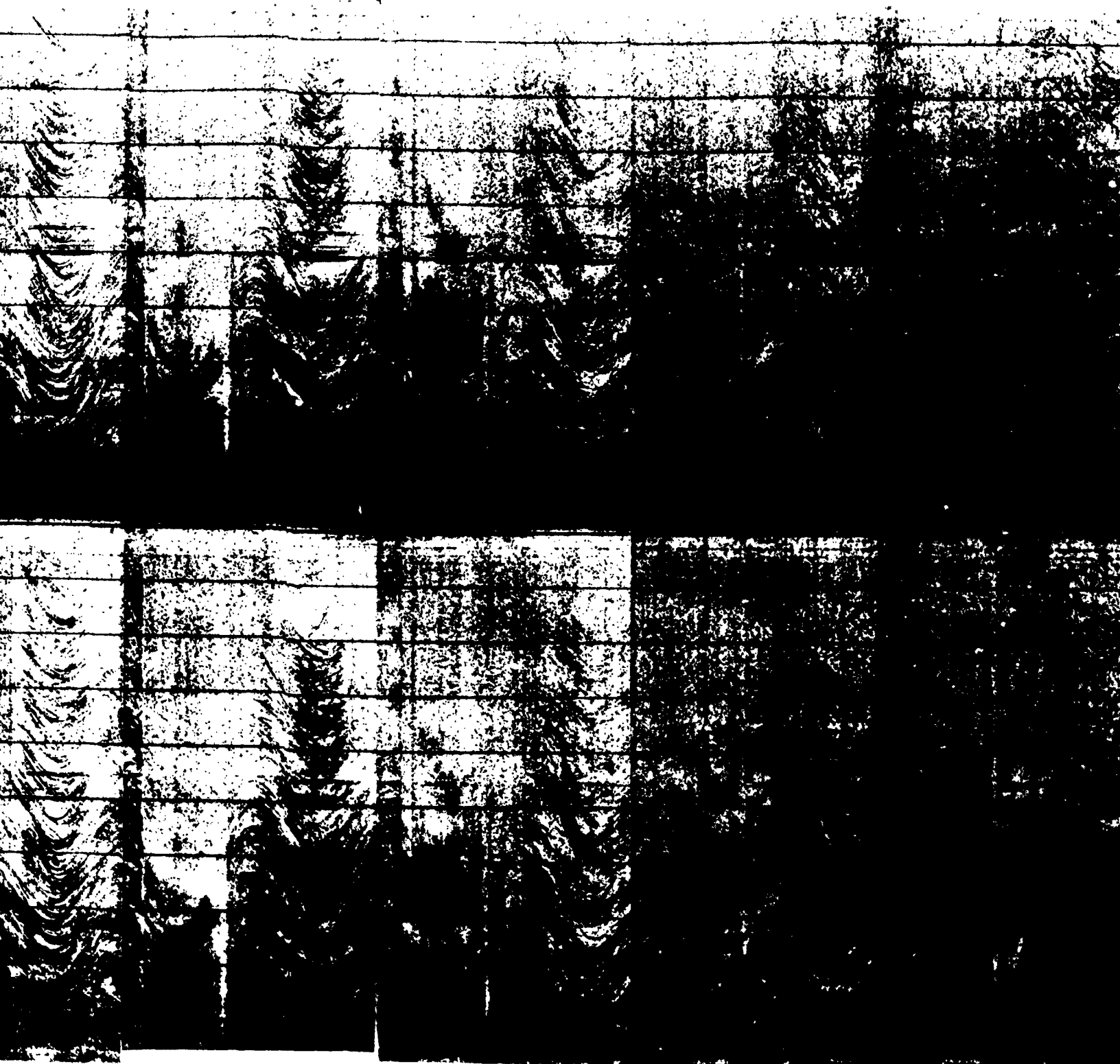


FIG.7 CONTINUOUS DISPLAY FROM 16th.

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12 0 12 0 12 0 12 1 12
18th 19th 20th 21st 22nd

FIG.7 CONTINUOUS DISPLAY FROM 16th. TO 26th AUGUST 1963

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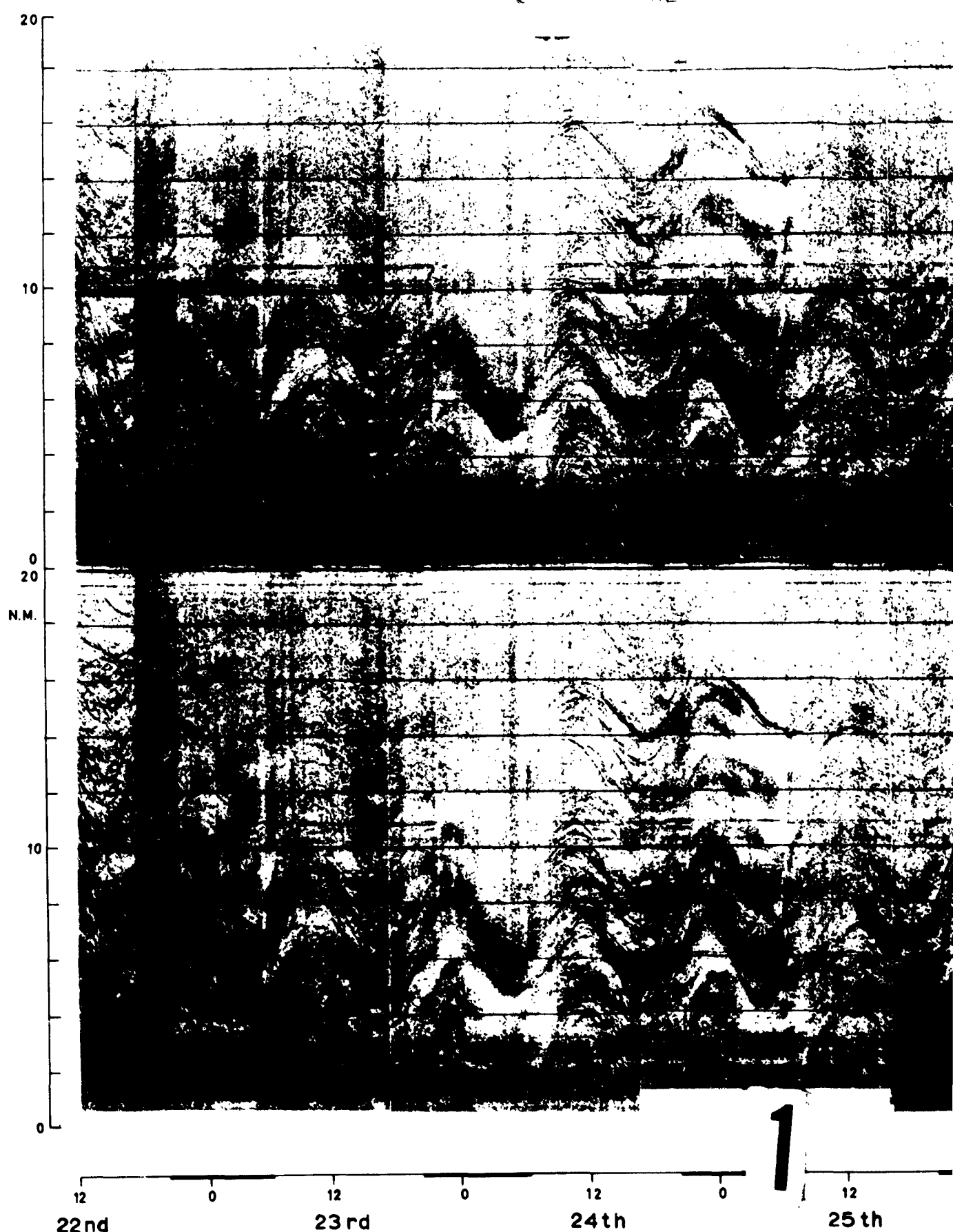


FIG. 7 (CONT.) CONTINUOUS DISPLAY FROM 16th TO 26th AUGUST

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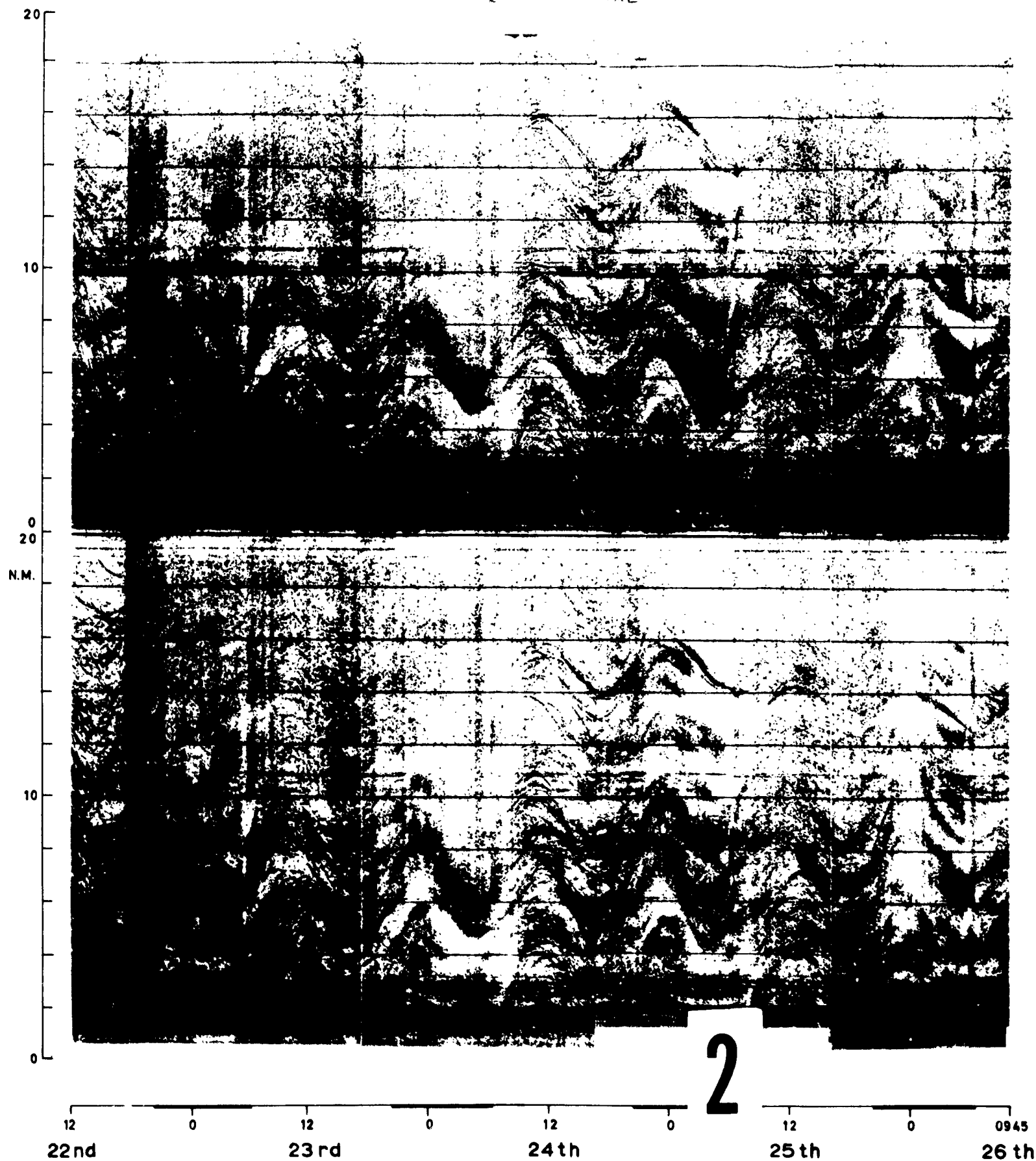


FIG. 7 (CONT.) CONTINUOUS DISPLAY FROM 16th TO 26th AUGUST 1963

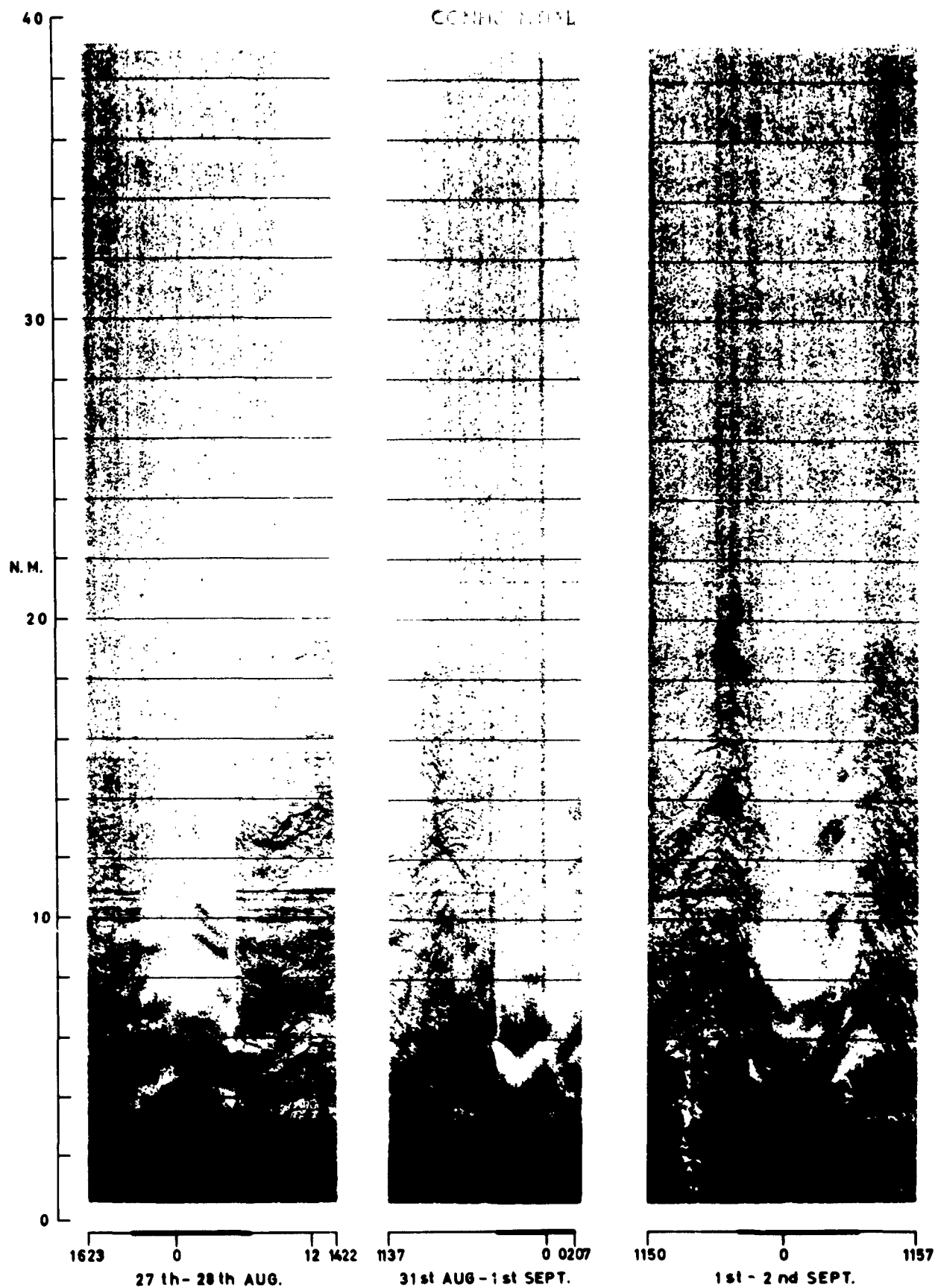


FIG.8 DISPLAYS BETWEEN 27 th AUGUST & 2 nd SEPTEMBER 1963

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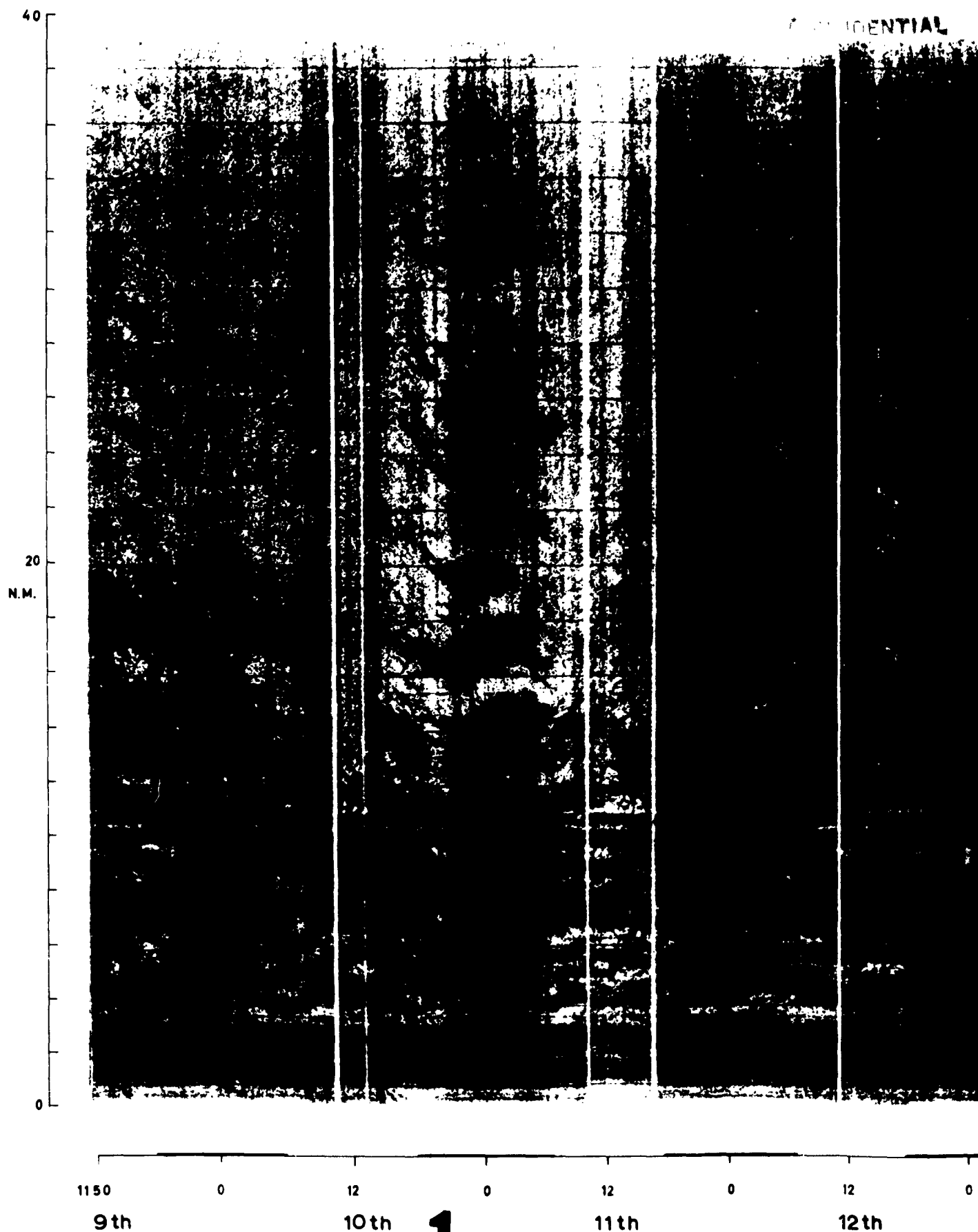


FIG. 9 CONTINUOUS DISPLAY FROM 9th TO

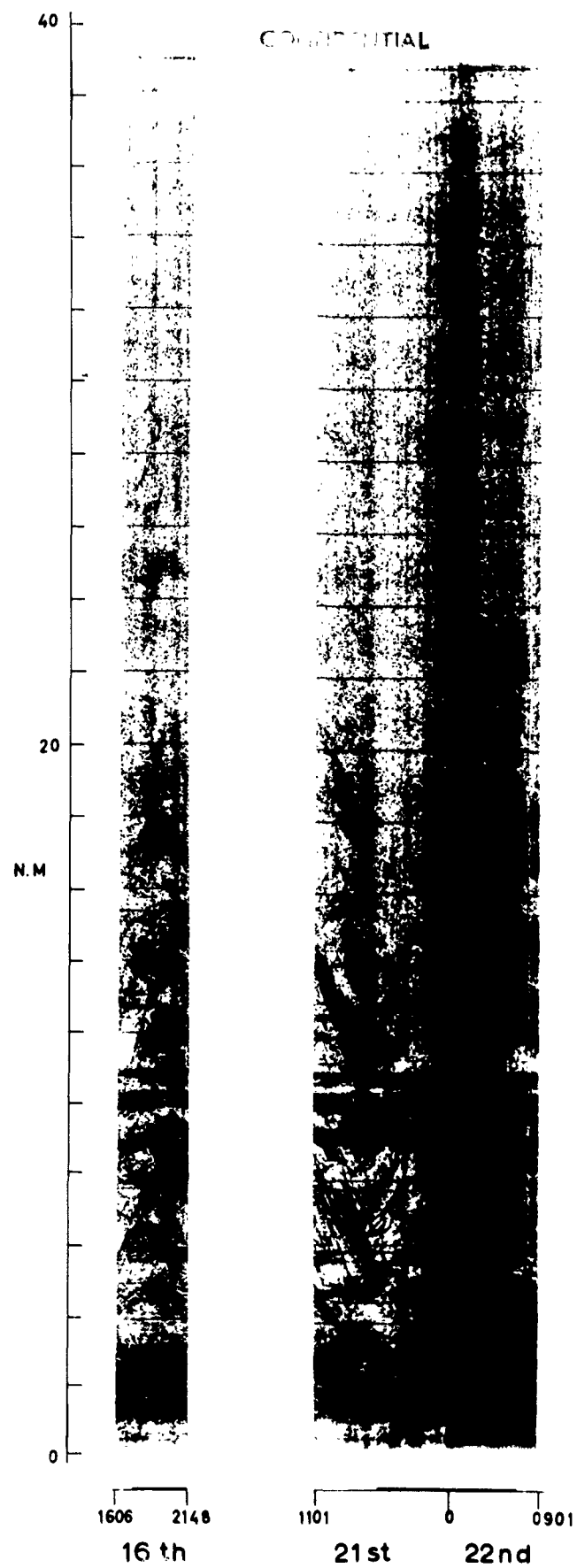


FIG. 10 DISPLAYS BETWEEN 16th AND 22nd
OCTOBER 1963

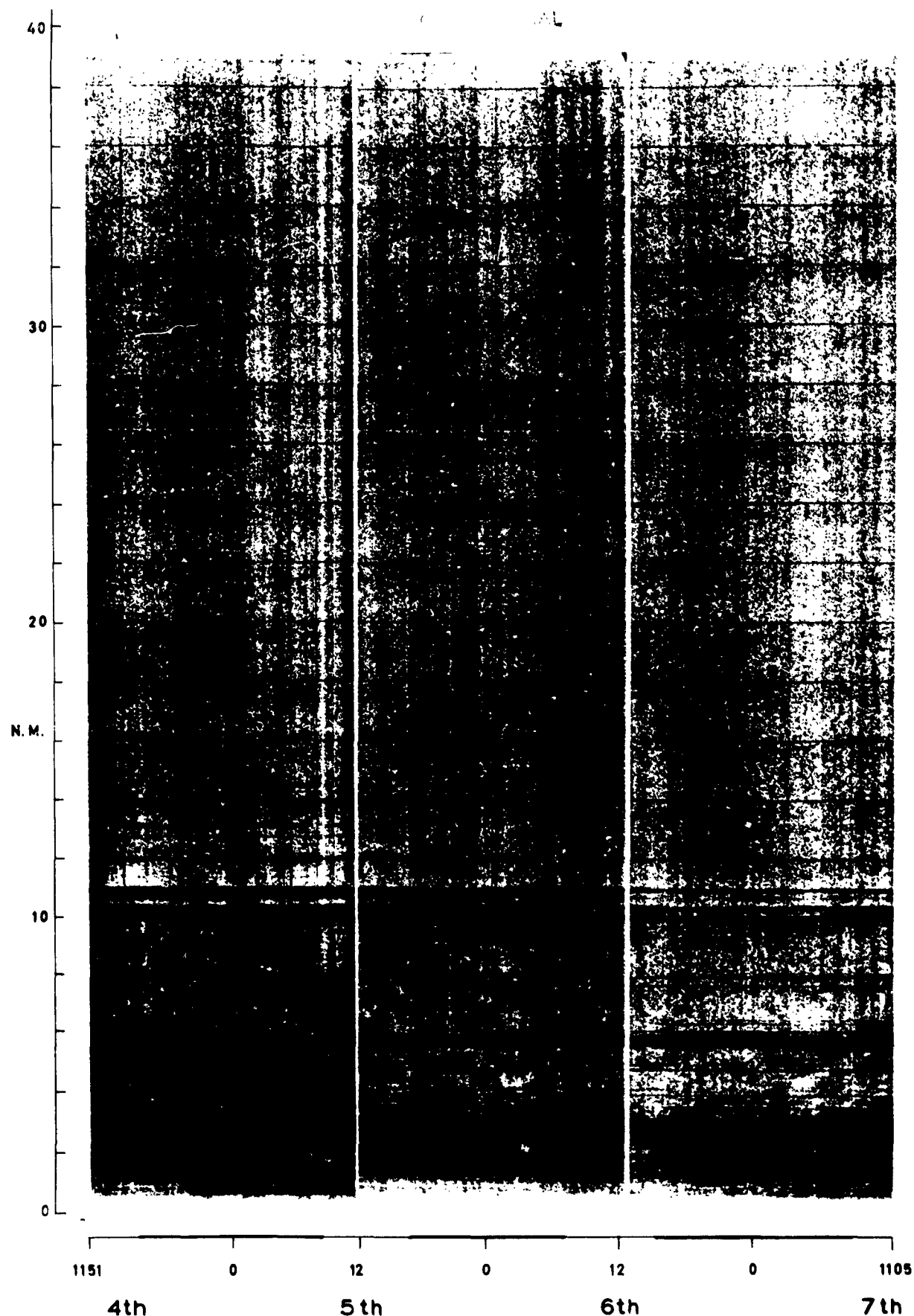


FIG. 11 CONTINUOUS DISPLAY FROM 4th TO 7th DECEMBER 1964

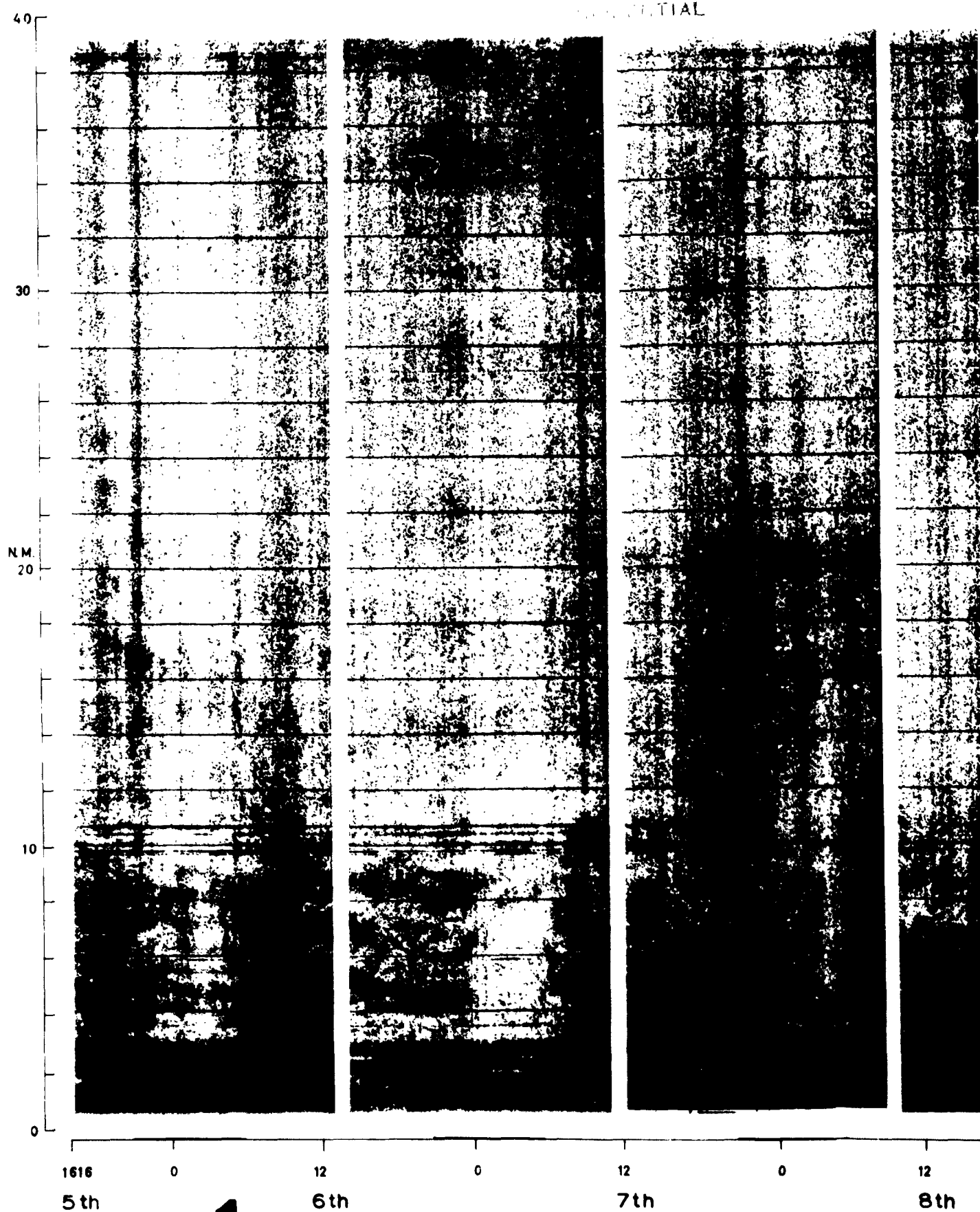


FIG. 12 CONTINUOUS DISPLAY FROM 5th TO 9th MAY 1964

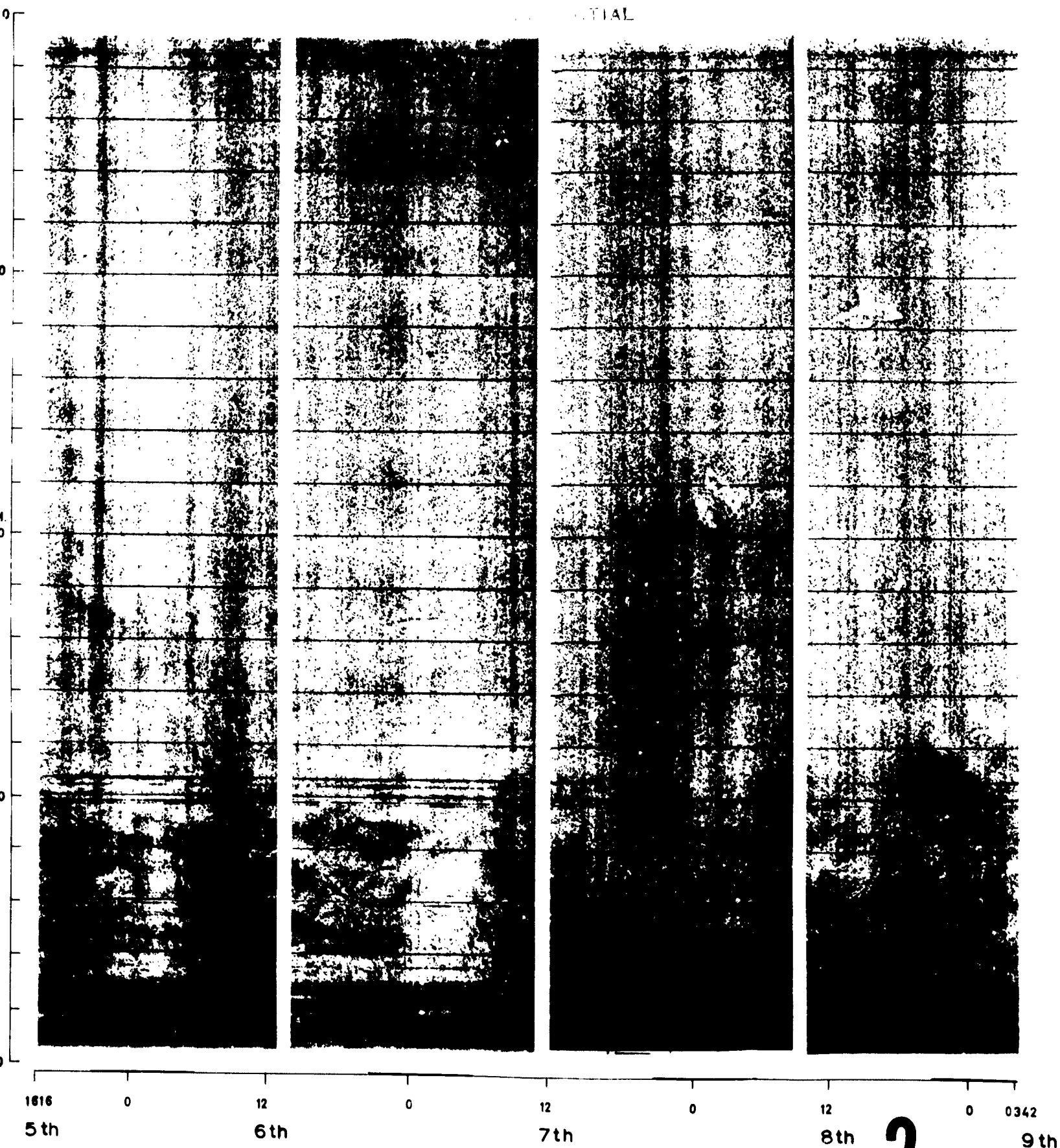


FIG. 12 CONTINUOUS DISPLAY FROM 5th TO 9th MAY 1964

A P P E N D I X

LIST OF FIGURES AND RECORDS

Figure	Date	Time	Range N.M.	Bearing Top Bottom	Transmission Top Bottom	Remarks
1	19th March, 1963 20th March, 1963 21st-22nd March, 1963 6th April, 1963	1034-2015 1013-1954 1357-1752 0946-2321	0-20	355° Axis	FM every 50 sec.	
2	20th-21st April, 1963 24th-25th April, 1963 1st-2nd May, 1963	1600-0850 1910-0822 1722-1907	0-40	Axis	FM every 100 sec.	Storm
3	14th-18th May, 1963	1547-1912	0-40	Axis	FM every 100 sec.	Storm on night of 14th/15th
4	21st May, 1963 23rd May, 1963 23rd-24th May, 1963	1133-1851 0914-1804 1829-1411	0-20	Axis	Noise every 50 sec. FM every 50 sec.	Lack of wrigglers partly due to their doppler
5	24th-25th May, 1963 30th-31st May, 1963	1435-1024 1415-1010	0-40	Axis	FM every 100 sec.	Wrigglers at 38 miles on last record
6	11th-15th June, 1963	1545-1737	0-40	Axis	FM every 100 sec.	
7	9th-11th July, 1963	1206-2055	0-40	Axis	FM every 100 sec.	
8	16th-26th August, 1963 27th-28th August, 1963	2032-0945 1623-1422	0-20	13° Axis	FM every 50 sec.	
9	31st Aug.-1st Sept. 1963 1st-2nd September, 1963 9th-14th October, 1963 14th-15th October, 1963	1137-0207 1150-1157 1150-1205 1235-1406	0-40 0-40 0-20	Axis Axis Axis	FM every 100 sec. FM every 100 sec. Noise every 50 sec. FM every 50 sec.	Discontinuities at 1405 & 1508 on 14th 1235-2220 10 ms. Pings 2311-1406 1000/s Noise 1 c/s OP filter
10	16th October, 1963	1606-2143	0-40	Axis	FM every 100 sec.	
11	21st-22nd October, 1963	1101-0991	0-40	Axis	FM every 100 sec.	
12	4th-7th December, 1963 5th-9th May, 1964	1351-1105 1616-0342	0-40 0-40	Axis Axis	FM every 100 sec. FM every 100 sec.	

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One-year collection of long-range echo records of fish behaviour
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